Invasions of isotopes and of neobiota

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Invasions with low diffusivity
in:
Materials science
Ecology

Synchrotron radiation study of Iron Diffusion

Aim: Use new possibilities of synchotron radiation for diffusion studies

Again: combine nuclear physics with materials science!

Earlier work e.g.:

G.V. and B.Sepiol in: Heitjans-Kärger book (2005),
Stadler et al., PRB, PRE (2004, 2006, 2007),
Sladecek et al., Surf.Sci. (2005),
Erdelyi et al., Science (2005)
Kmiec et al., PRB (2007), Stankov et al., PRL (2007), Vogl et al., PRL (2007),

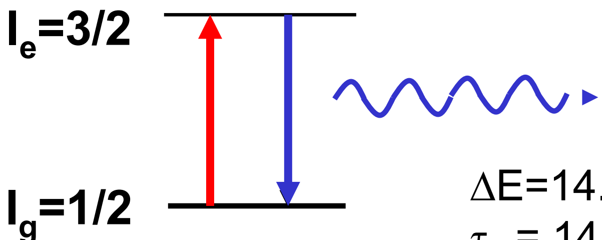
European cooperations (Austrian Science Ministry, 6th framework EU)

Synchrotron radiation
= very intense X-rays

Earlier work used coherency, polarization
for introducing new methods in diffusion

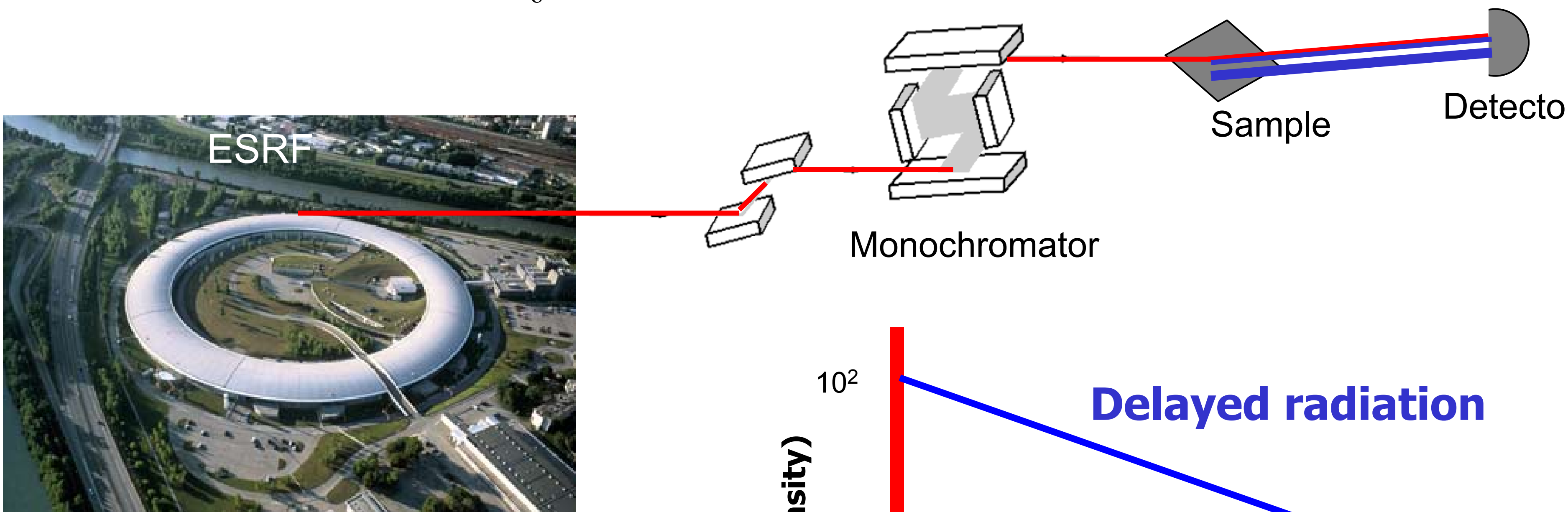
Here:
New method which takes advantage
of the high brilliance of synchrotron radiation.

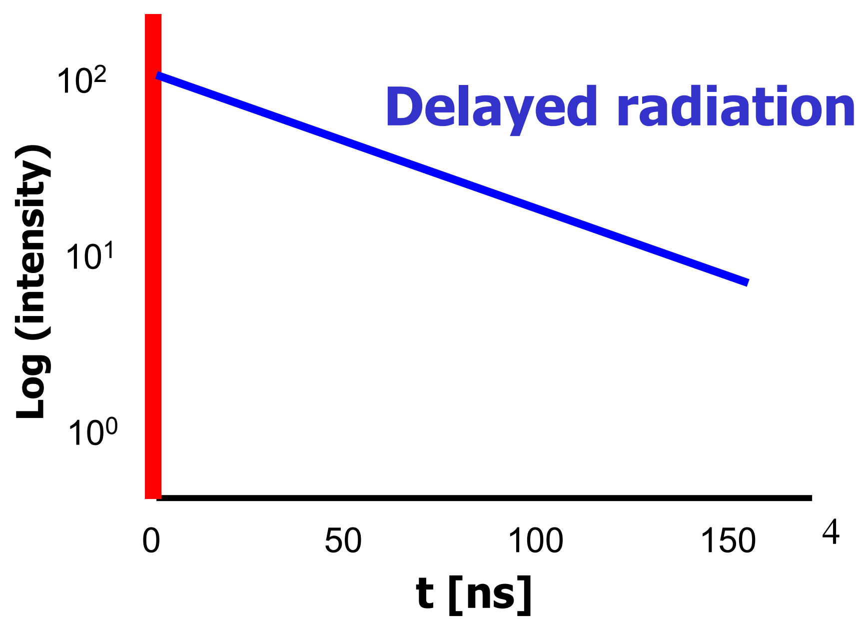
Nuclear Resonant Scattering (NRS)



^{57}Fe Mössbauer isotope

ΔE=14.4 keV
τ_o = 141 ns



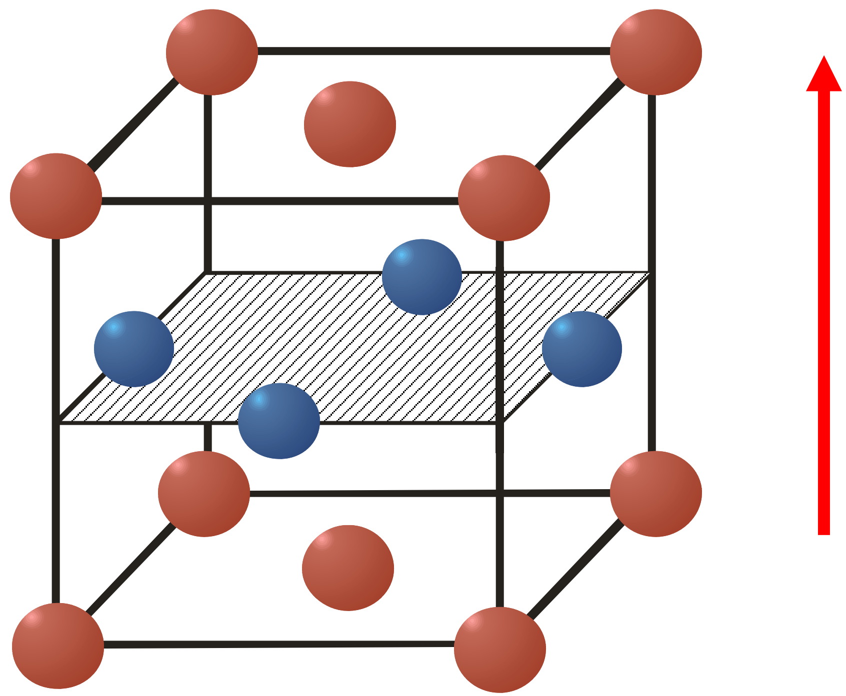


Team of R.Rüffer, ESRF

Cracow groups of
J. Korecki, R. Kozubski

Nuclear radiation (sees only ^{57}Fe)
re-emitted with delay

is used for DIFFRACTION studies.



Fe-diffusion

Magnetic storage material with high storage density

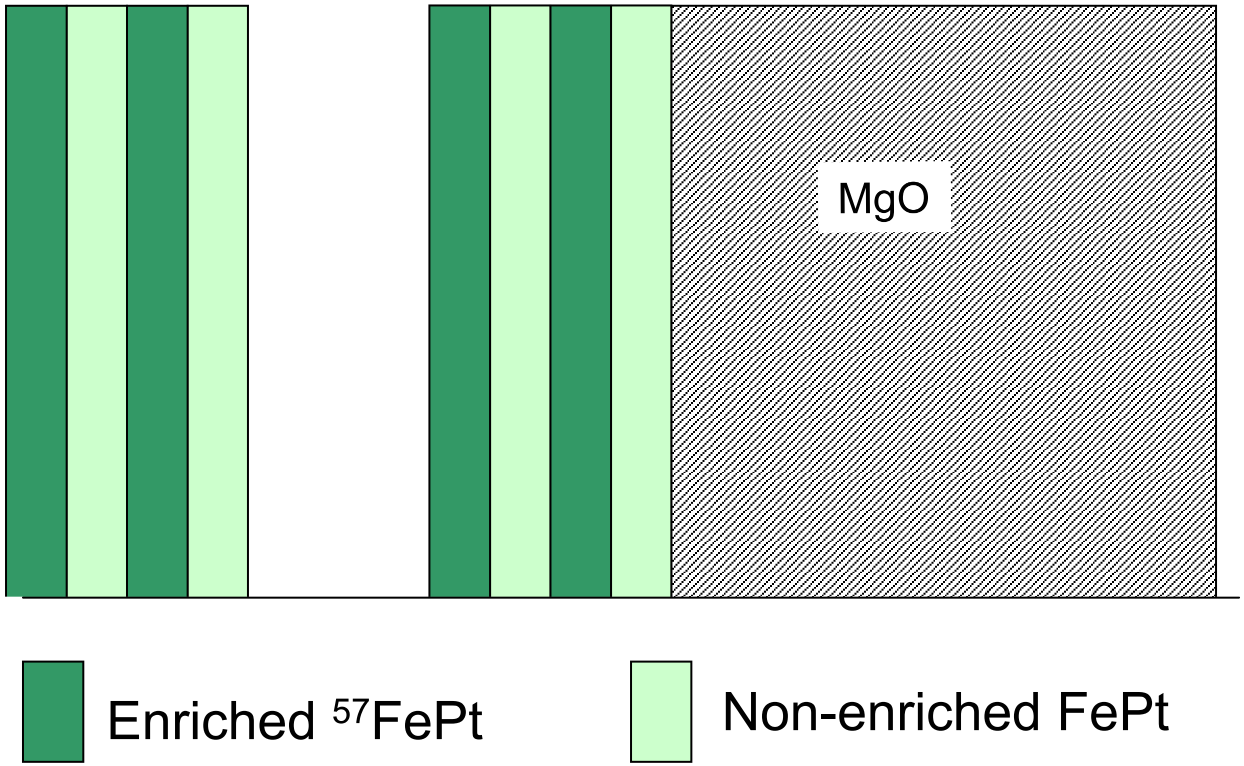
FePt

$L1_0$

See poster by M.Rennhofer et al.
A 4 Re-Orientation Behaviour of c-Variant FePt Thin Films

Sample

Instituut voor Kern- en Stralingsfysica,
K.U. Leuven



Chemically homogeneous, but „isotopically“ layered structure

Bragg diffraction of delayed radiation from layered structure

How to study self-diffusion of Fe?

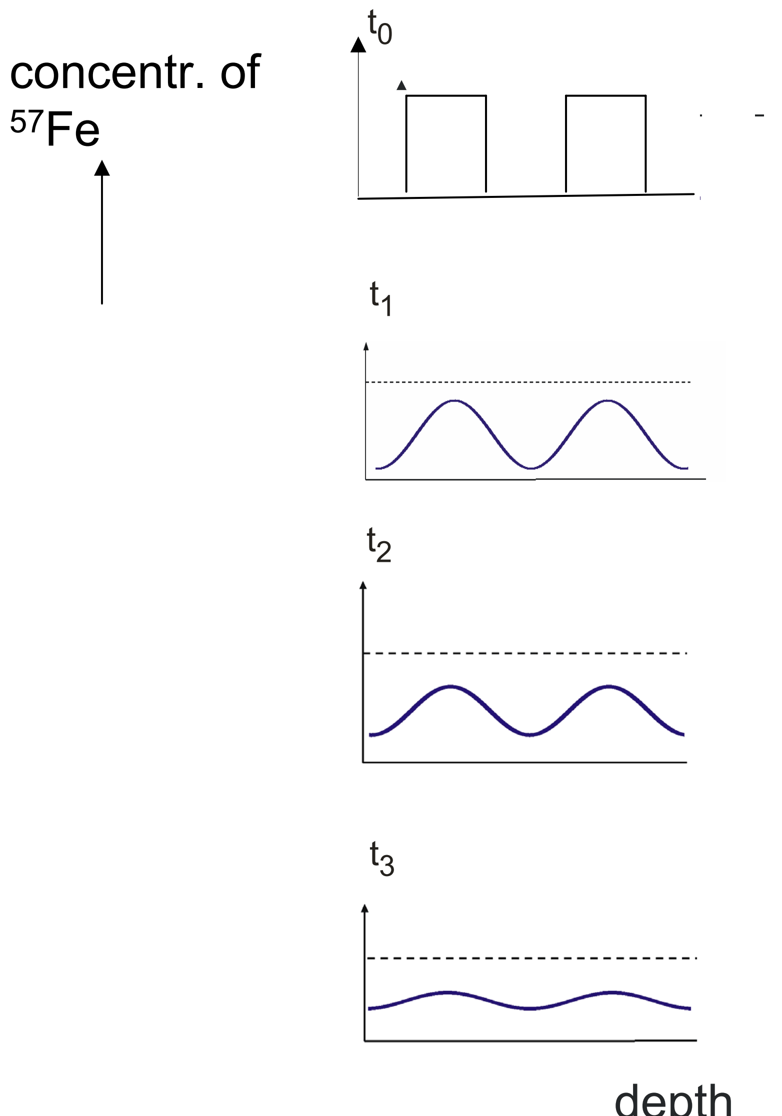
Follow height of superstructure Bragg peak produced by delayed radiation from ^{57}Fe as a function of annealing time!

Gupta et al. (2005) for amorphous material

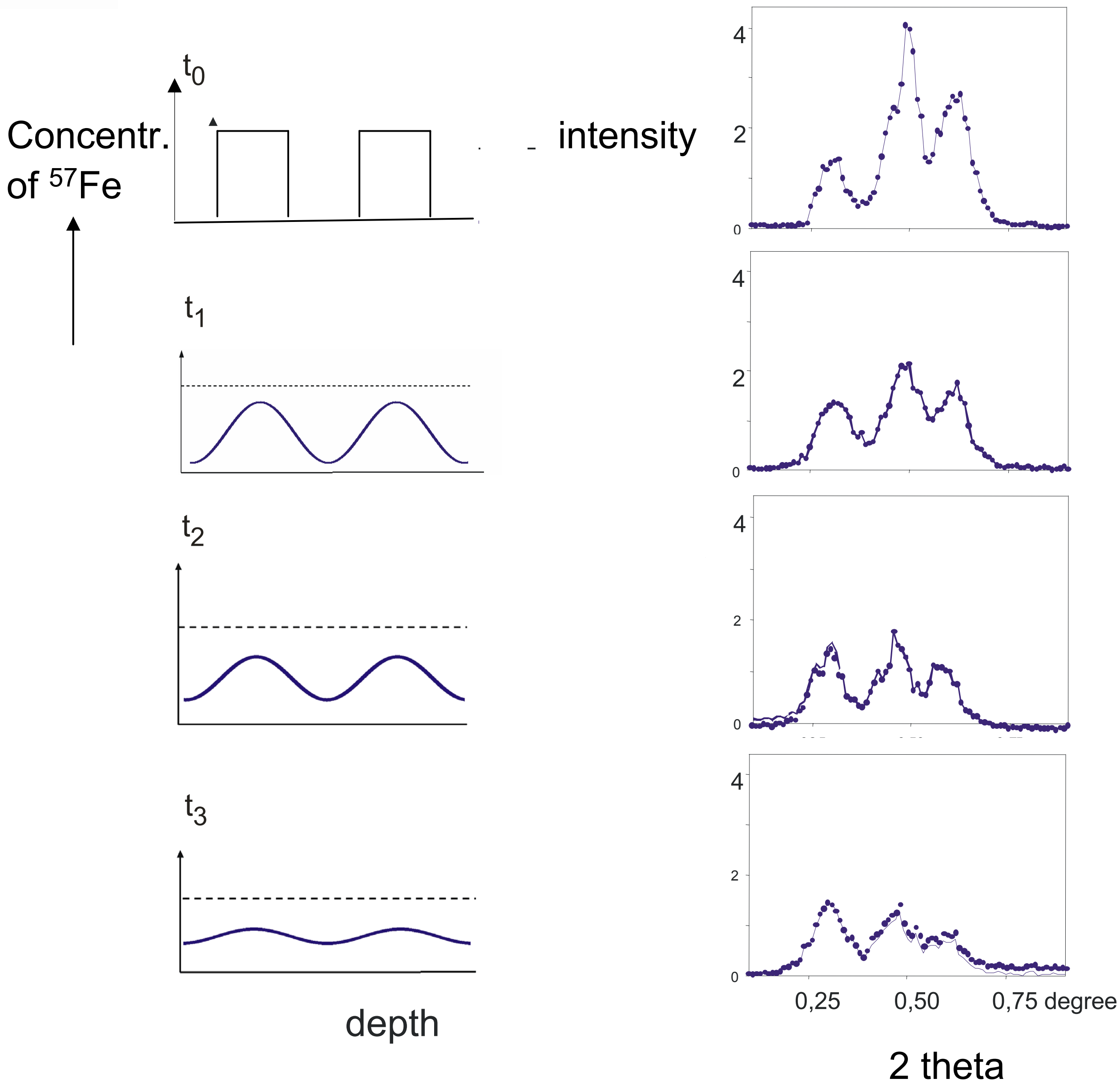
Historical:

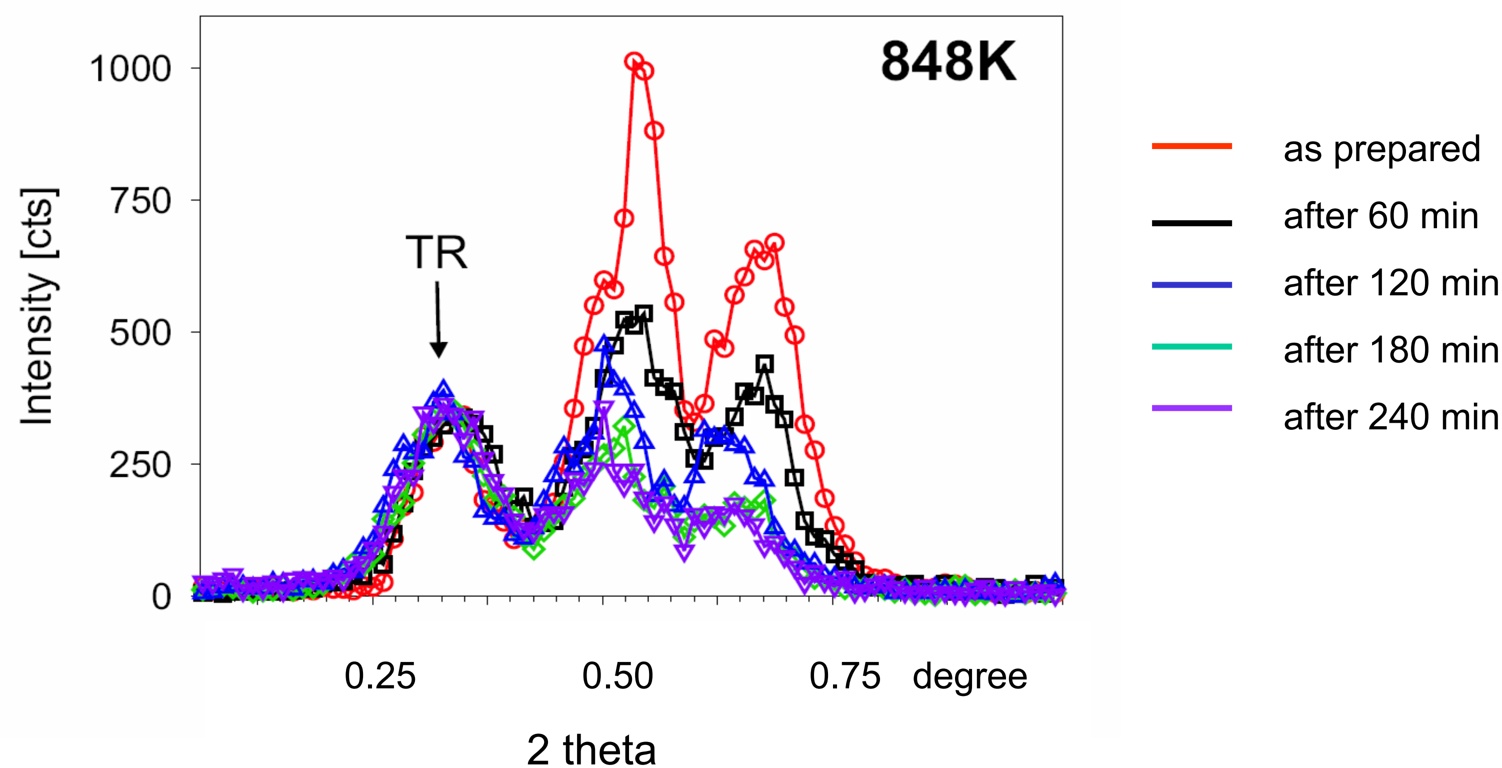
Youtz & DuMond (1940) studied chemical diffusion with X-radiation

What do we expect on annealing at higher temperature?

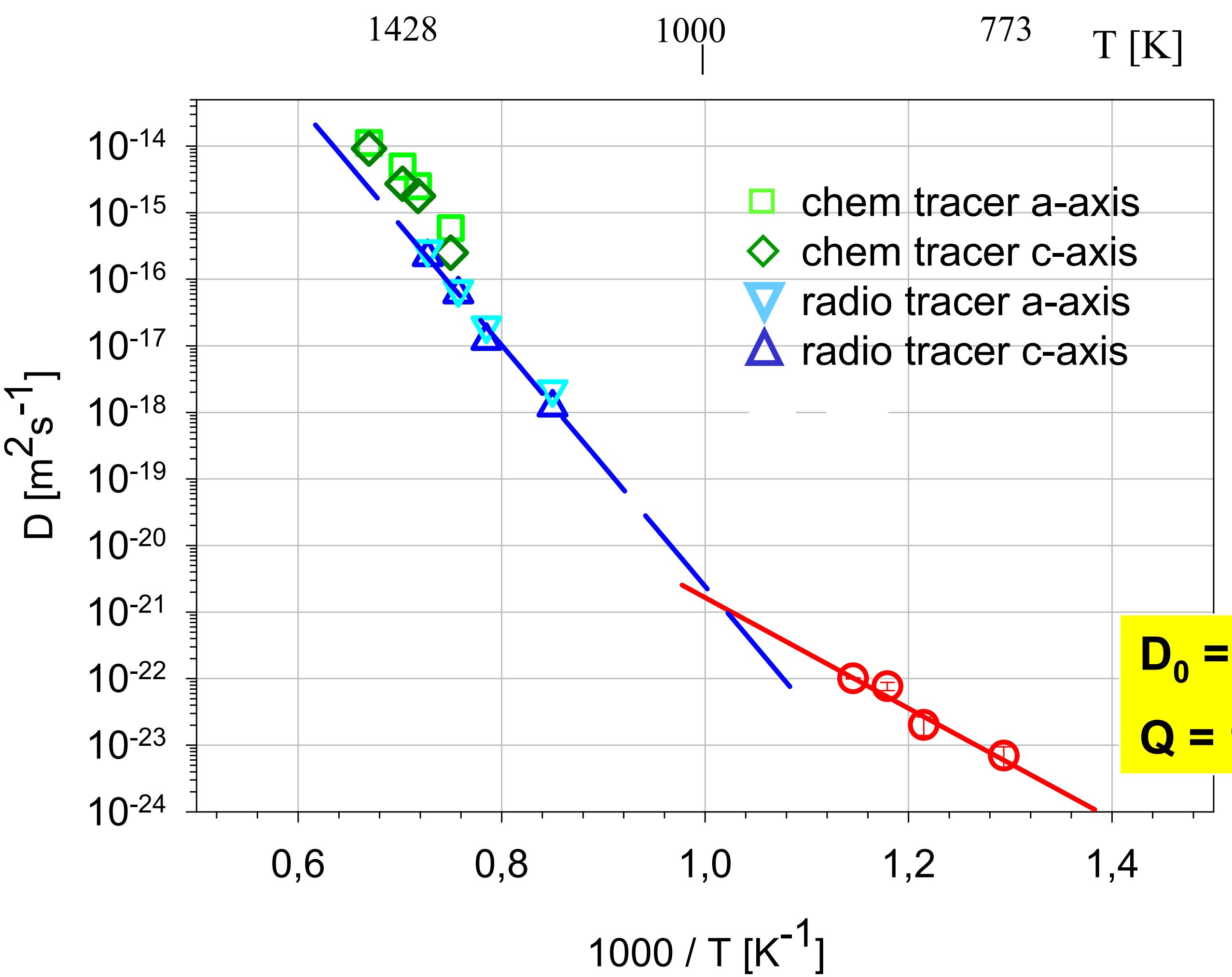


Superstructure Bragg peaks




848K
TR
1000
750
500
250
0
Intensity [cts]
0.25
0.50
0.75
degree
2 theta
as prepared
after 60 min
after 120 min
after 180 min
after 240 min

Results diffusion of iron in FePt



$D_0 = 3.5(4) \times 10^{-13}\ m^2s^{-1}$

$Q = 1.65(30)\ eV$

Conclusion

New method for very slow diffusivities

Diffusion mechanism at low temperatures differs from mechanism at high temperatures

See posters

A 4 Re-Orientation Behaviour of c-Variant FePt Thin Films

Marcus Rennhofer et al.

Ref.: M. Rennhofer et al., PRB 2006

A 3 Lateral Diffusion Spreading of Two Competitive Intermetallic Phases along Free Surface (System Cu-Sn)

Yu. Kaganovskii, L.N. Paritskaya, V.V. Bogdanov

Simulating spread („invasion“) of ragweed (Ambrosia artemisiifolia) in Austria

- The American common ragweed, is an annual plant which has been invading Central Europe for 150 years.

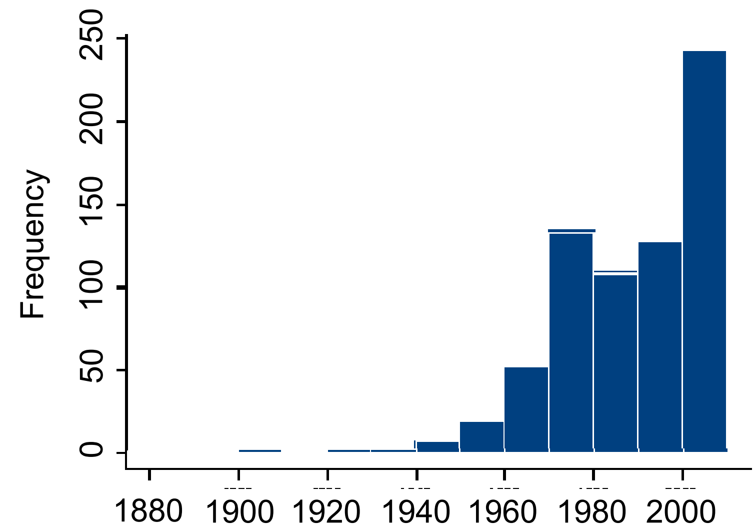
- Pollen evokes heavy allergies and because of its spread rather late in summer causes a second wave of allergy when other pollen allergies have decayed.

- Here consider the progressive extension of its habitat due to climatic change for predicting dispersal (“diffusion”) in the coming decades.

Common ragweed
(Ambrosia artemisiifolia)

Why study the ragweed?

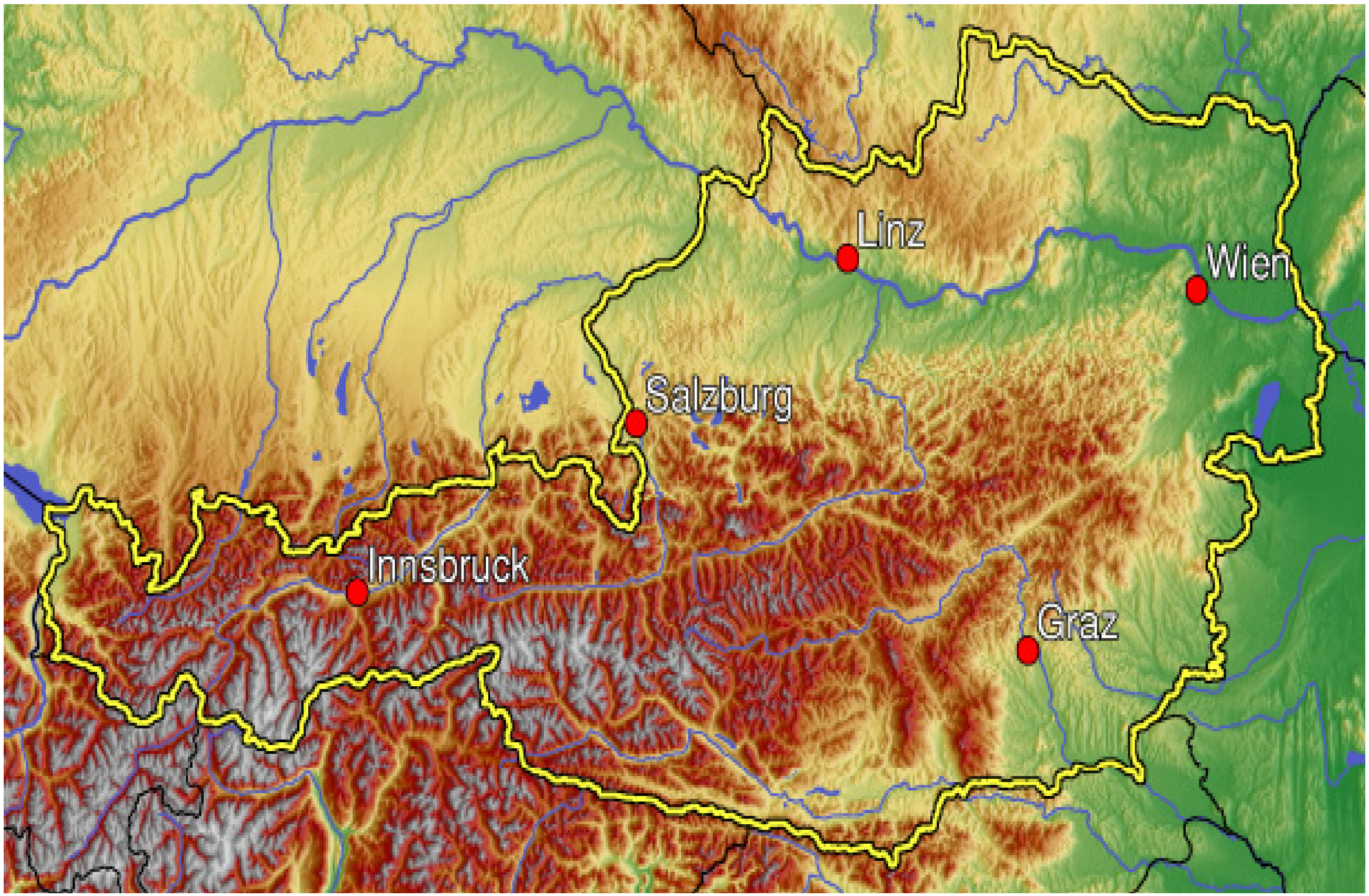
- Availability of accurate distribution data in Austria



- Rapidly spreading

- Annual plant→ fast succession of generations enables it to rapid response to climatic changes

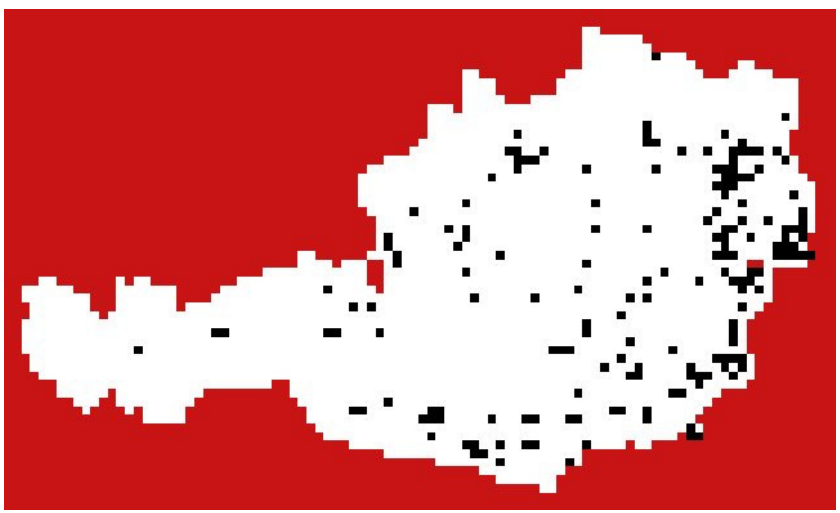
Austria



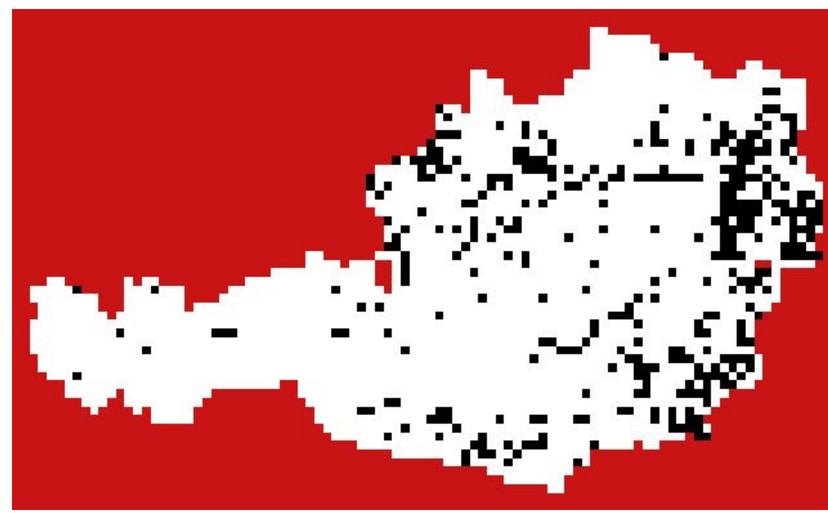
Aim:
Predict spread of ragweed under changing climatic conditions

1st: **Simulate progressive infestation by ragweed from 1990 to 2005**

subdivide Austria into 2612 grid cells (about 5 x 6 km)

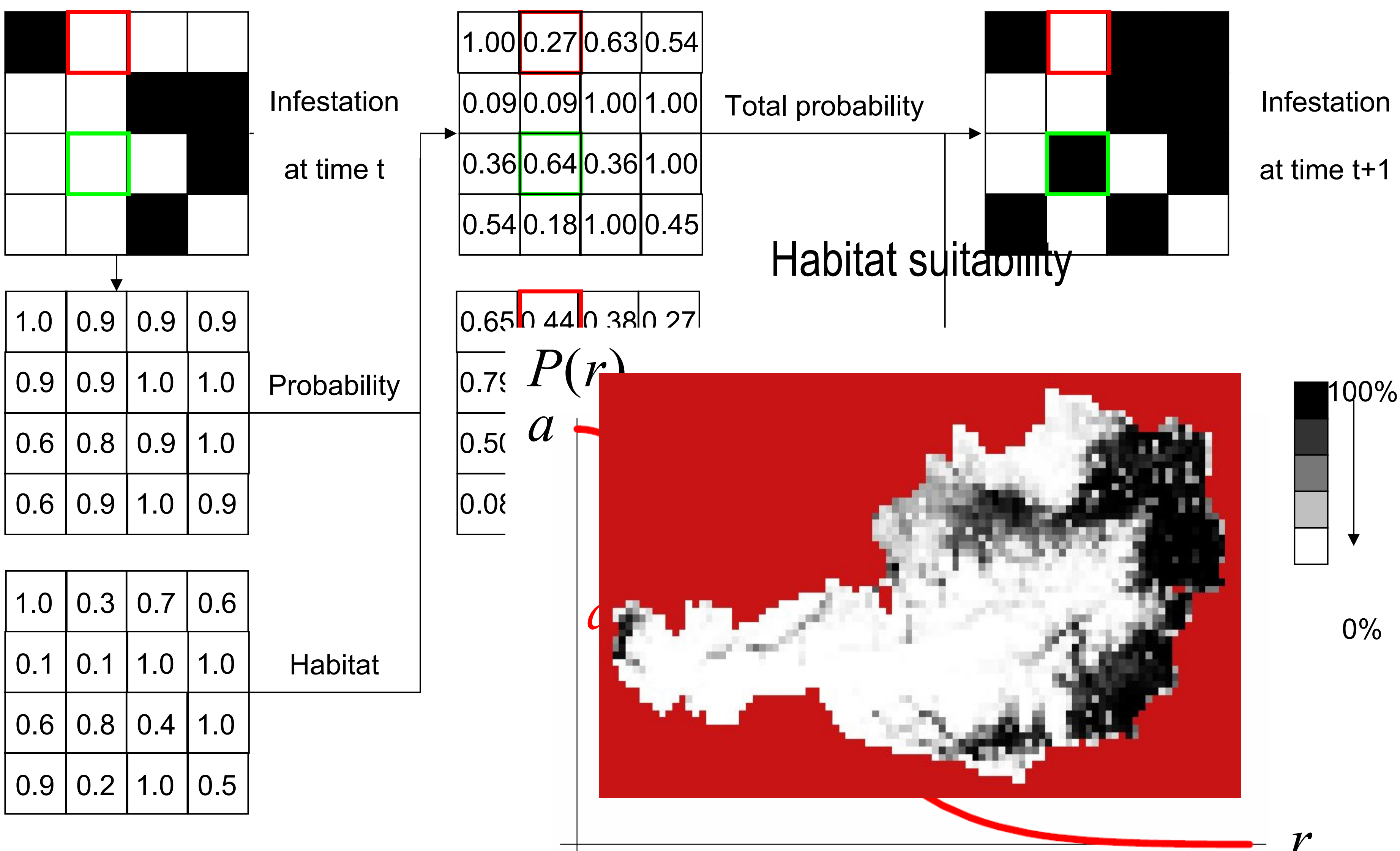


1990: starting point



2005: end point

Method [1]: iterative algorithm



[1] Gilbert et al. (2004)

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M. Smolik: Stochastic optimization

Repeat 100 times

Simulation 2005

Infestation status 2005

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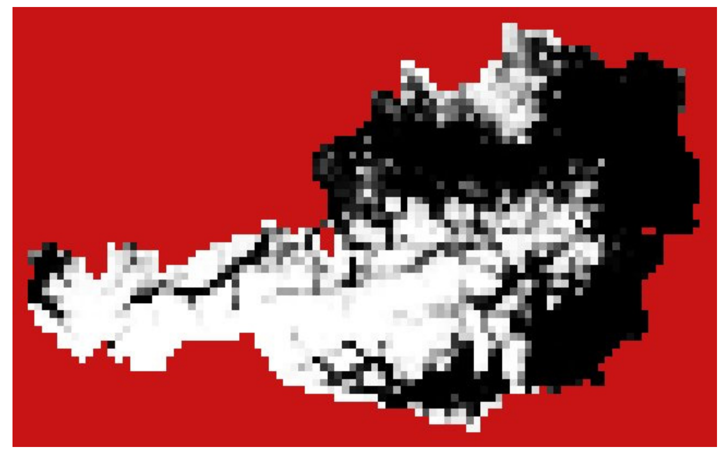
2nd: Predictions for habitat of ragweed

Current climate



2050: Regional (+2.3°C)
Gobiet et al. (2006)

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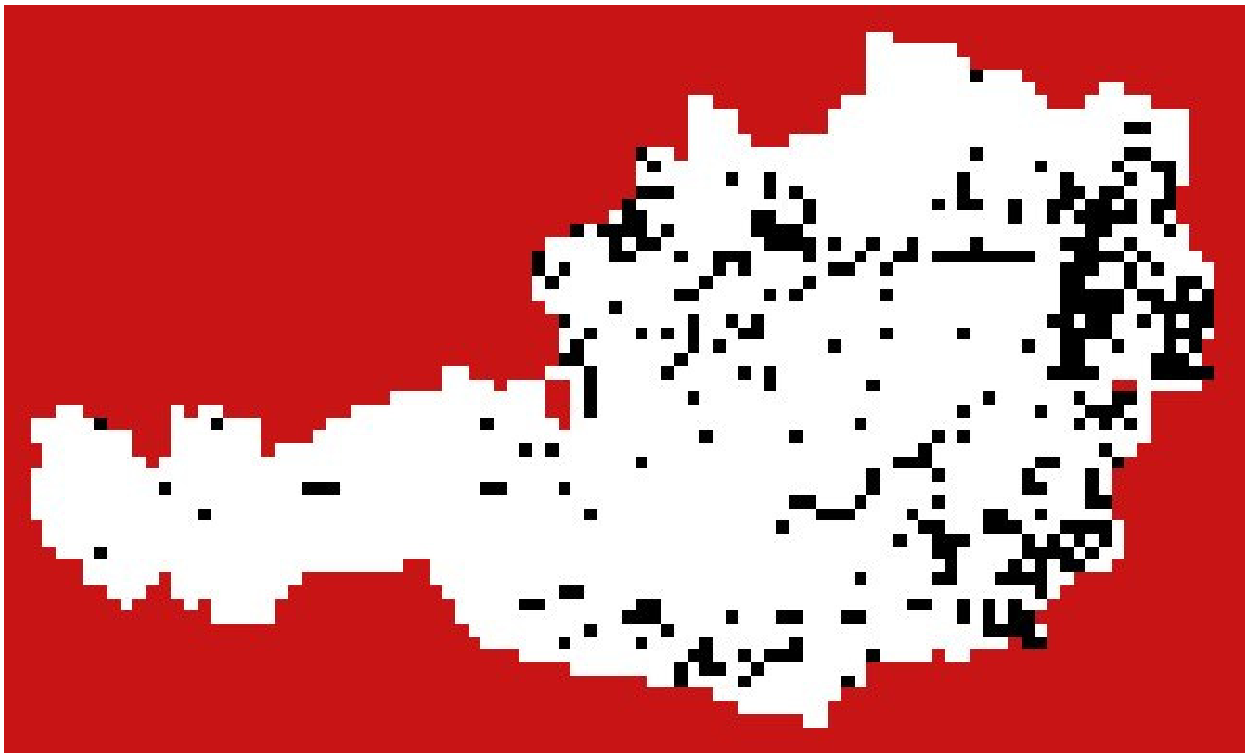
3rd: Outlook for spread of ragweed
on basis of

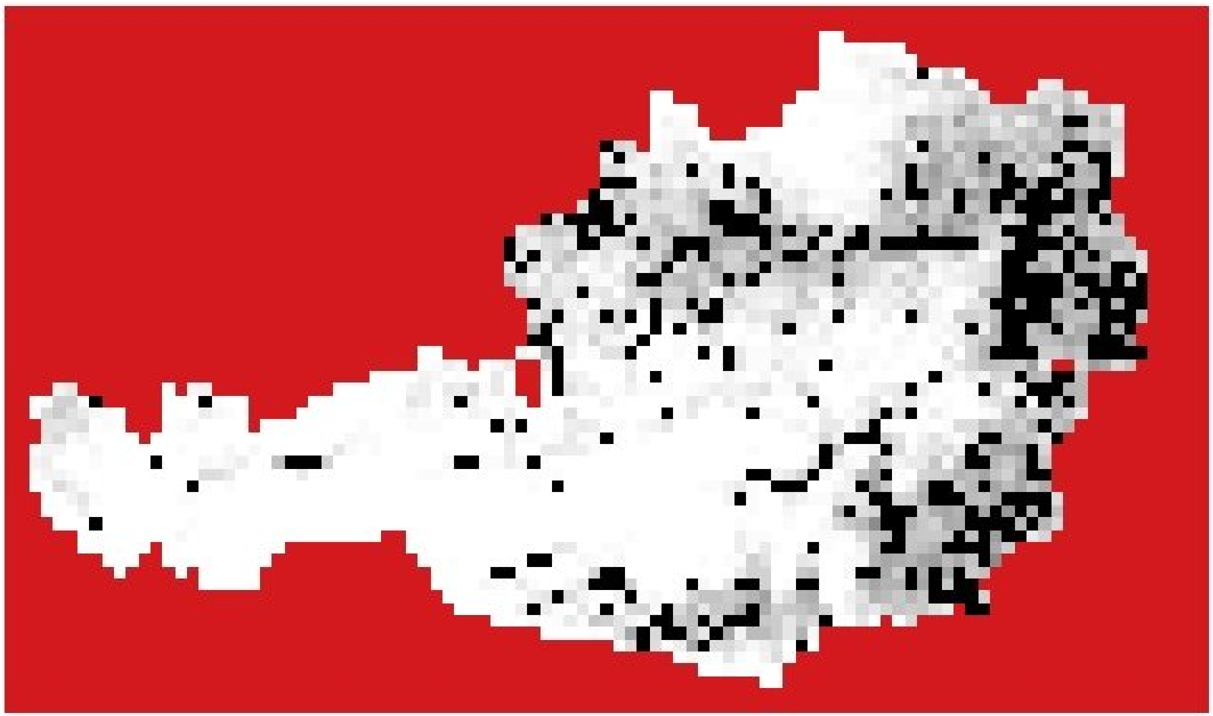
- **diffusion model** (1990-2005)

- **habitat prediction** (+2.3°C until 2050)

Status 2005



Prediction for 2020



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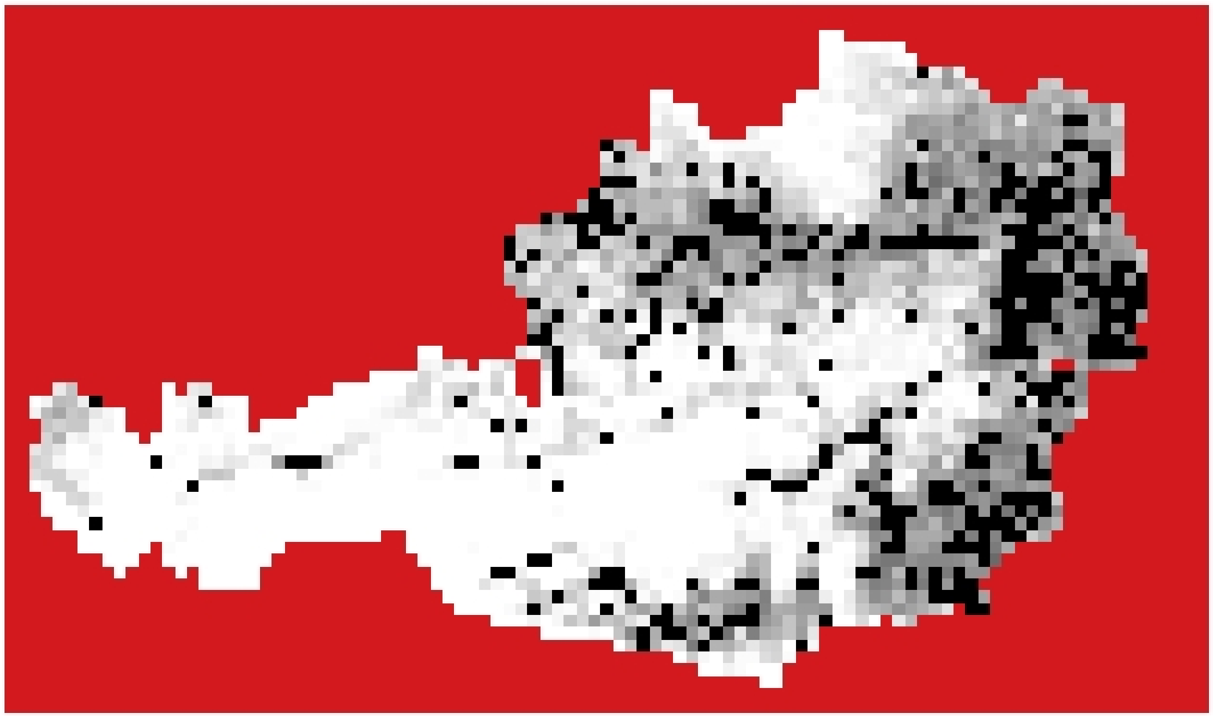
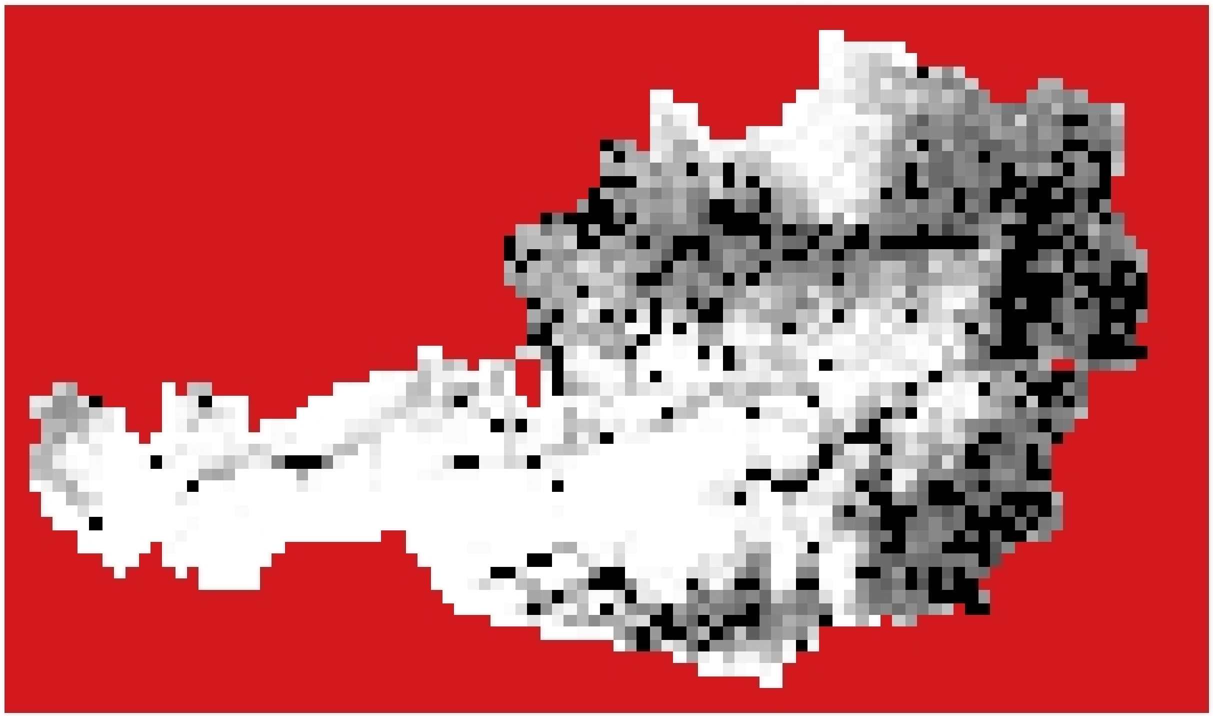
Prediction for 2030



Prediction for 2040



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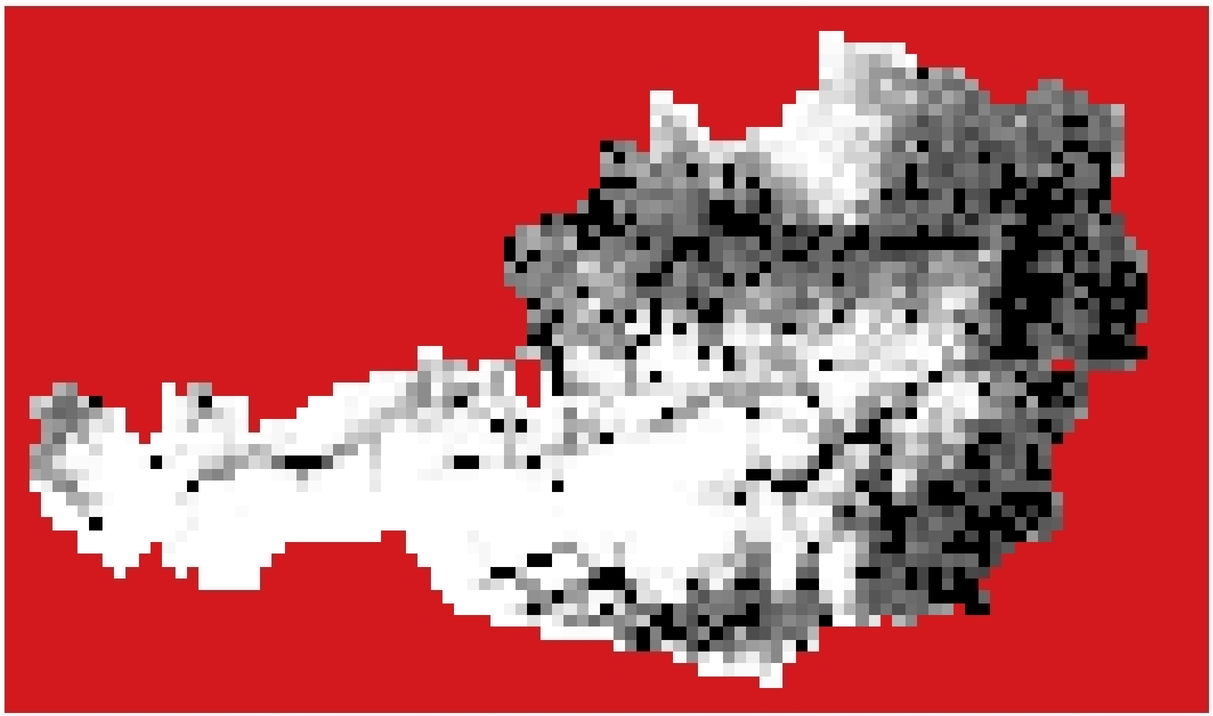
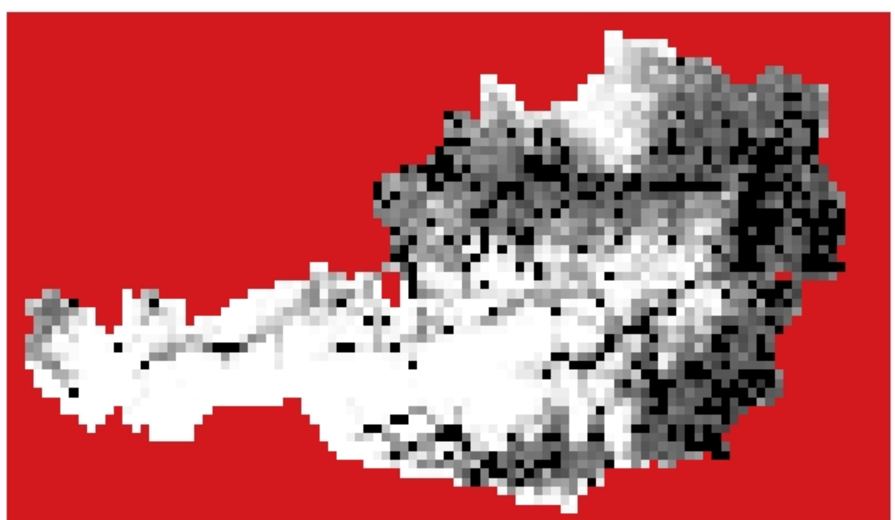
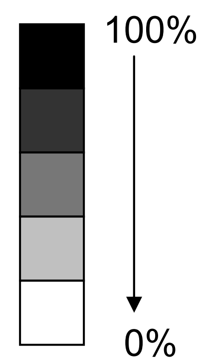
Prediction for 2050



Regional Prediction for Habitat of ragweed in 2050

Prediction for Spread (Diffusion) of ragweed in 2050





Conclusion

American ragweed

(Ambrosia artemisiifolia)

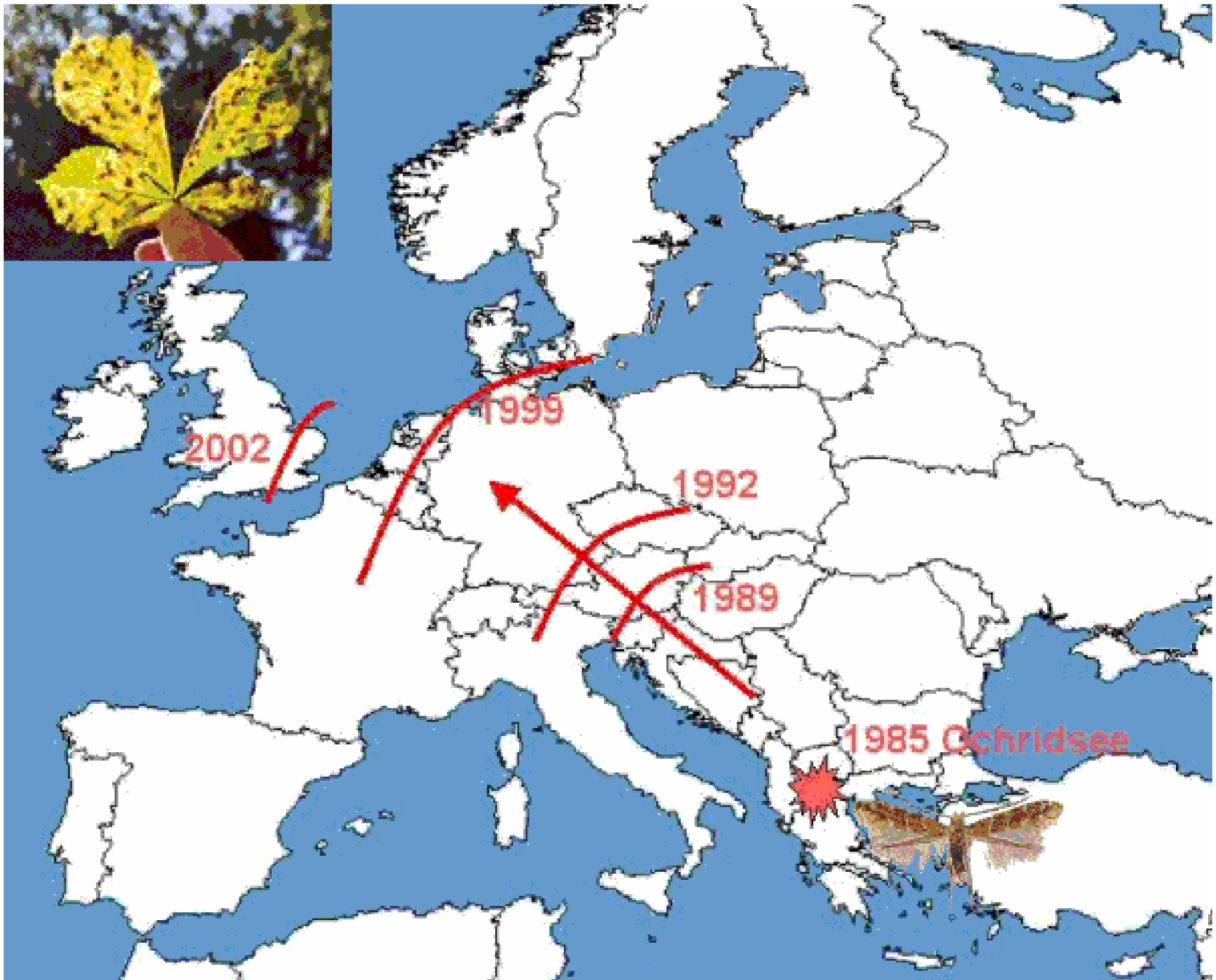
Rather slow diffusion

Poster B9
Effects of Superspreaders in Spread of Epidemic (SARS)
Ryo Fujie, Takashi Odagaki

Seeds of plants are no superspreaders, at least not for ragweed

But animals are (horse-chestnut leaf miner moth, Gilbert et al.)

Spread of horse-chestnut leaf miner moth
(Gilbert et al. 2004)

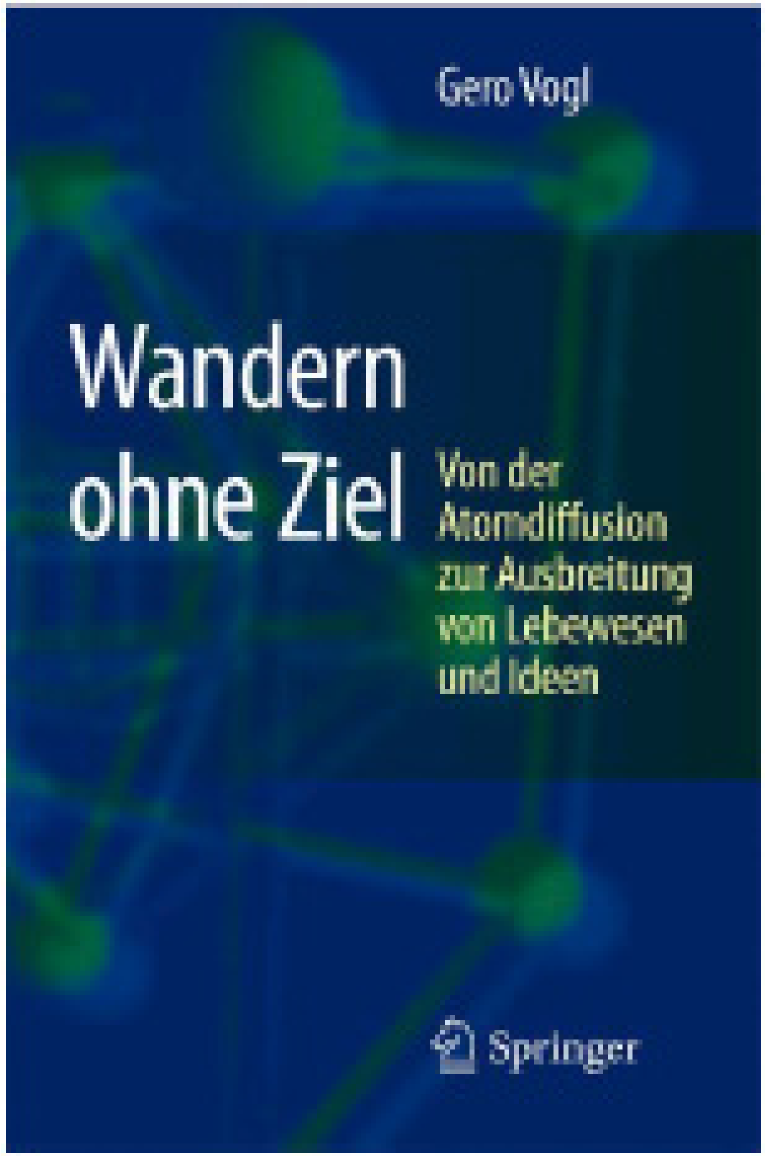


Thank you for accompanying me
on my Brownian motion („Wandern ohne Ziel“)
through so different provinces
of the vast realm of diffusion

Gero Vogl,

„Wandern ohne Ziel.
From the Diffusion of Atoms to the Spread of Living Beings and Ideas“,

Springer, 2007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Springer